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Assessment Of The Socio-Economic Effects Of Distributed Energy Development (Microgrids And Rooftop Solar Generation) In The Context Of Uzbekistan

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Abstract: The article provides a comprehensive assessment of the socio-economic effects of implementing distributed energy (distributed generation), including microgrids and rooftop solar power plants, in the context of Uzbekistan. Based on an analysis of the current state of the energy sector, characterized by high energy intensity and significant infrastructure deterioration, the potential and direct benefits of decentralized solutions are examined. It is demonstrated that, in addition to direct economic benefits in the form of reduced fuel costs and network losses, distributed energy contributes to enhancing energy security, creating new green jobs, improving the quality of electricity supply for the population, and reducing environmental impacts. Practical recommendations have been developed for government authorities, businesses, and international partners to accelerate the energy transition.

Introduction

Uzbekistan's energy sector is on the verge of large-scale transformation. The traditional model based on large thermal power plants operating on fossil fuels faces growing challenges, including significant physical and technological depreciation of equipment, substantial grid losses, increasing domestic demand, and environmental commitments [2]. Under conditions where nearly 50% of final energy consumption is attributed to buildings, while GDP energy intensity remains among the highest in the region, the conventional approach of expanding centralized generation capacities is becoming increasingly costly from both economic and environmental perspectives [3].

An alternative approach is represented by the paradigm of distributed energy, which involves electricity generation close to consumption centers, including through the use of renewable energy sources (RES). Its key components include microgrids (local energy systems capable of autonomous operation) and rooftop solar panels. The active development of this sector corresponds to the strategic objectives of the Republic of Uzbekistan aimed at diversifying the energy balance, where the share of renewable energy sources reached approximately 24% of installed capacity by early 2025 [2], improving energy efficiency, and ensuring sustainable economic growth.

Relevance of the Research Topic

The relevance of studying the socio-economic effects of distributed energy for Uzbekistan is determined by a combination of interconnected factors.

First, the imperative of energy security and efficiency. The deterioration of heating networks and boiler facilities results in enormous losses, while the economy's dependence on natural gas limits export potential [2]. It is expected that by 2030, the demand for energy resources will increase by 1.5 times [1]. Distributed generation, particularly based on renewable energy sources (RES), reduces the burden on outdated grids and enables the release of natural gas for other purposes. As a representative of the World Bank noted as early as 2013, investments in energy efficiency help avoid even greater costs associated with expanding energy supply capacity [3].

Second, socio-economic disparities and regional development. Problems related to reliable energy supply are particularly acute in densely populated areas such as the Fergana Valley and remote rural

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regions [2]. Microgrids and solar panels can provide stable and high-quality electricity supply to these territories, contributing to their economic development and improving the quality of life of the population.

Third, state policy and international commitments. The government of Uzbekistan is taking active steps by establishing the National Energy Efficiency Agency aimed at reducing energy consumption in the economy by 20% by 2030 [1]. Specific plans have been adopted for installing solar panels at 142 textile enterprises and social facilities, constructing 300 small solar power plants, and developing 1,000 small hydropower plants [1]. Assessing the effects of these initiatives is essential for policy adjustment and attracting further investment.

Research Aim and Objectives

Research Aim:

To conduct a multi-criteria assessment of the expected socio-economic effects of the large-scale implementation of distributed energy technologies (microgrids and rooftop solar power plants) in Uzbekistan and to develop practical recommendations for stakeholders.

Research Objectives:

1. To analyze the current state and structural challenges of Uzbekistan's energy sector that determine the potential for distributed generation.
2. To classify and quantitatively assess the direct economic effects (cost reduction and fuel savings) of implementing distributed energy solutions based on the example of ongoing government programs.
3. To identify and analyze social and indirect economic effects, including improved energy security, job creation, and environmental improvement.
4. To develop proposals for institutional, financial, and regulatory measures that contribute to scaling up positive outcomes.

Analysis of the Socio-Economic Effects of Distributed Energy

The development of distributed energy has a multi-level impact on the economy and society of Uzbekistan. These effects can be systematized into three main areas.

1. Economic Effects: Direct Financial Benefits and Investments

The most evident effect is the direct financial savings for consumers and the state. According to plans for 2026, the installation of solar panels at 142 textile enterprises will enable annual savings of 722 million kWh of electricity and 693 billion soums [1]. A larger-scale program involving the construction of small solar power plants and micro-hydropower plants aims to save 2.6 billion kWh of electricity and 1.1 billion cubic meters of natural gas as early as 2025 [1]. These savings directly contribute to increasing the competitiveness of industry.

A key driver is attracting investment. In 2026, $264 million from international financial institutions is planned to be attracted solely for the modernization of 770 social facilities [1]. The development of the energy service company (ESCO) market, which has also been announced at the government level, will create a new economic sector where private businesses invest in energy efficiency and generation projects, generating income from the resources saved by clients [1].

2. Social Effects: Quality of Life, Employment, and Regional Development

Social effects are equally significant:

Improvement of energy supply reliability: Microgrids are capable of providing uninterrupted power supply for hospitals, schools, residential areas, and enterprises during disruptions in the centralized grid, which is particularly important for densely populated regions and social stability [2].

Creation of new jobs: The deployment of small-scale solar power plants and micro-hydropower plants, the development of the ESCO sector, and the production and maintenance of solar equipment will generate demand for qualified engineers, technicians, installers, and energy auditors, contributing to employment opportunities, including in regional areas [1].

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Support for households: Subsidies and compensation programs for improving residential energy efficiency (150 billion soums in 2026), combined with opportunities to install solar panels, will reduce the burden on family budgets by lowering utility costs [1].

3. Macroeconomic and Systemic Effects: Security and Sustainability

At the macroeconomic level, distributed energy contributes to addressing systemic challenges:

Energy security: Reduced dependence on imported equipment for thermal power plants and diversification of the energy mix through locally available renewable energy resources.

Grid load reduction and postponement of modernization investments: Generation at the point of consumption reduces power flows and losses in distribution networks, which are currently extremely high in Uzbekistan [2].

Environmental impact: Replacing the combustion of natural gas and coal reduces greenhouse gas emissions and other pollutants, supporting environmental objectives and improving living conditions.

Table 1: Summary Assessment of the Potential Socio-Economic Effects of Distributed Energy in Uzbekistan.

Table 1. Summary Assessment of the Potential Socio-Economic Effects of Distributed Energy in Uzbekistan

Effect Category	Specific Manifestations	Example / Potential (Based on Data for 2025–2026)
Direct economic	Reduction of enterprises' electricity costs	Savings of 693 billion soums at 142 textile enterprises [1]
	Savings of public funds on fuel resources	Planned savings of 1.1 billion m^3 of natural gas and 2.6 billion kWh of electricity [1]
	Attraction of foreign investment	$264 million for the modernization of social facilities [1]
Social	Improvement of energy supply reliability	Special approach to ensuring energy supply in the Fergana Valley [2]
	Creation of new jobs	Formation of the ESCO market, demand for installers and service engineers [1]
	Reduction of the burden on household budgets	Housing energy efficiency subsidies (150 billion soums) [1]
Systemic (macroeconomic level)	Enhancement of energy security	Diversification of the energy balance and reduction of peak loads on the grid
	Reduction of environmental impact	Replacement of fossil fuels and reduction of emissions
	Promotion of technological development	Implementation of digital technologies and artificial intelligence for energy audits [1]

Conclusions and Recommendations

1. Distributed energy is not merely a supplement but a strategic necessity for Uzbekistan, offering a comprehensive solution to the challenges of high energy intensity, infrastructure deterioration, and increasing energy demand [2, 3].
2. Direct economic effects (reductions in enterprise costs and state budget expenditures on fuel resources) have already been quantitatively assessed within the framework of government programs and demonstrate a significant scale, amounting to hundreds of billions of soums and billions of kilowatt-hours of electricity savings [1].

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3. Social effects (improving energy supply reliability in vulnerable regions, creating green jobs, and supporting the population) represent a key argument for accelerating the transition, as they directly affect quality of life and social stability [1, 2].
4. The main barriers to large-scale implementation remain the need to adapt the regulatory and legal framework, develop financing mechanisms for small businesses and households, and address the shortage of qualified specialists.

Recommendations:

1. For Government Authorities:

Accelerate regulatory reforms: The effective operation of the unified regulator being established for the energy and housing and communal services sectors should focus on simplifying procedures for connecting microgeneration facilities to grids and establishing fair tariffs for the purchase of generated electricity [1].

Expand financial instruments: In addition to subsidies for social facilities, it is necessary to develop preferential lending programs or green mortgage schemes for households and small and medium-sized enterprises (SMEs) interested in installing solar panels.

Launch educational programs: Introduce courses on the design, installation, and maintenance of renewable energy equipment in vocational colleges and universities to develop the necessary human resource capacity.

2. For Businesses and Investors:

Actively develop the ESCO model: Energy service companies should become drivers of modernization in the public sector and industry by providing comprehensive turnkey solutions with guaranteed energy savings [1].

Invest in localization: Develop assembly and service production facilities for solar energy components, taking into account the scale of the planned market [1].

3. For International Partners and Financial Institutions:

Focus on projects with multiplier effects: Support not only the construction of energy facilities but also programs aimed at developing local renewable energy businesses, technology transfer, and strengthening institutional capacity.

Facilitate knowledge exchange: Finance pilot projects involving smart microgrids in rural areas and small towns that can serve as scalable models for broader implementation.

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